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Head-Up Display (HUD)

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Head-Up Display

Model: E60, E61, E63, and E64

Production: Start of Production MY 2004

OBJECTIVES

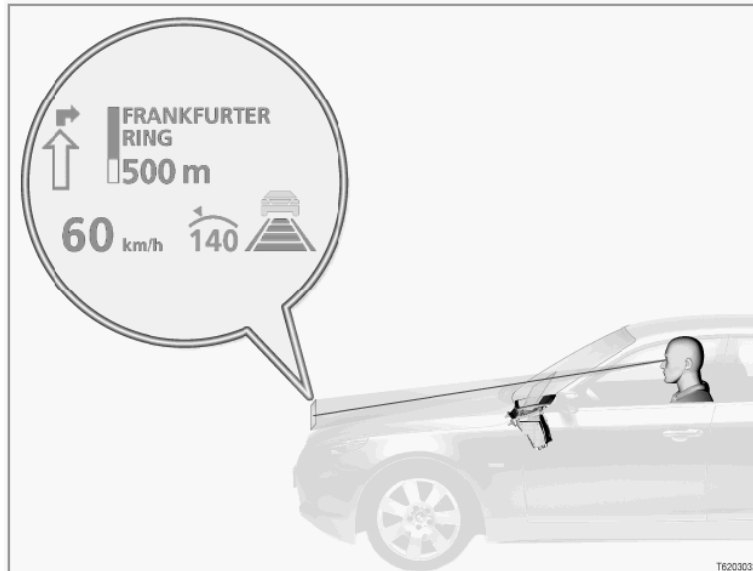
After completion of this module you will be able to:

- List the advantages of the HUD
- Name the components of the HUD
- Explain HUD operation
- Perform HUD self test
- Align HUD with special tools

Head-Up Display

The HUD, now available on the E60, E61, E63 and E64, is used to display relevant information needed for driving the vehicle. The information is displayed as a virtual image on the windshield. The image is projected into the driver's field of vision which creates the illusion that the image is at the front edge of the hood.

The relevant driving information is still available in the instrument cluster and CID.



Depending on the equipment installed in the vehicle, this virtual image contains information that is of relevance to the driver, such as:

- Cruise control FGR
- Active Cruise Control ACC
- Navigation
- Check Control messages
- Road speed

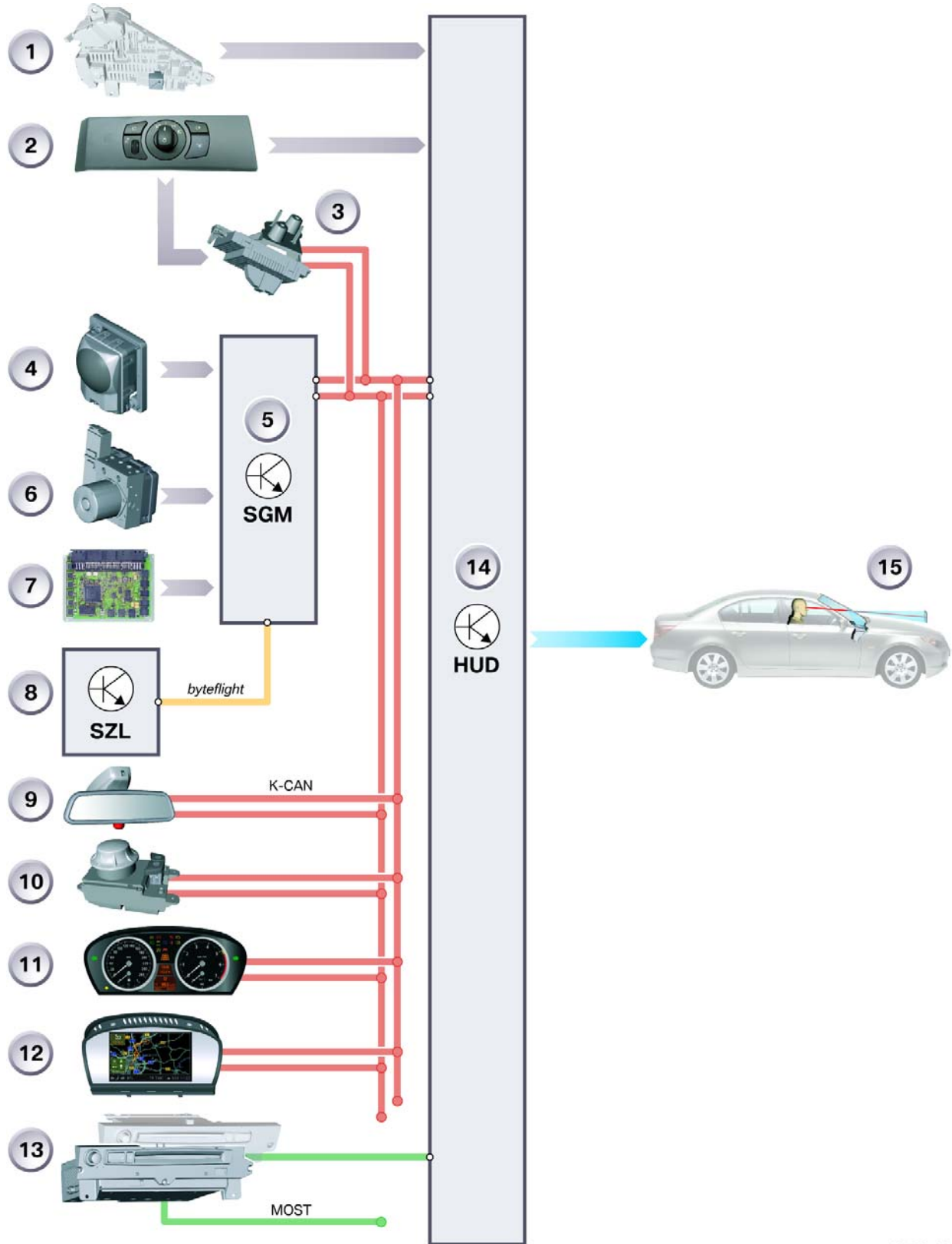
The size of the virtual image is approximately 200 mm x 100 mm.

The HUD of the E60 and E61 are identical. Due to the angle of the the windshield on the E63 and E64, the HUD is slightly modified. The mounting position in the instrument panel and the mirrors in the HUD unit are altered to allow integration of HUD into the 6 series.

Advantages of the Head-Up Display

The virtual image in the driver's field of vision allows the driver to concentrate more on the road ahead than previously. Driving is thus rendered less fatiguing. For example, the driver switches his vision between the instrument cluster and road traffic less frequently. This makes driving more relaxing, the eyes do not have to re-focus as frequently.

HUD System Overview



Legend for System Overview

Index	Explanation	Index	Explanation
1	Power distribution, rear	9	Rain and Light Sensor (RLS)
2	HUD Switch	10	Controller
3	Light Module (LM)	11	Instrument Cluster
4	Active Cruise Control (ACC)	12	Central Information Display (CID)
5	Safety and Gateway Module (SGM)	13	M-ASK or CCC
6	Dynamic Stability Control (DSC)	14	Head-up Display (HUD)
7	Digital Motor Electronics (DME)	15	Head-Up Display Projection Image
8	Steering Column Switch Cluster (SZL)	16	

Components

The HUD system is comprised of the following components:

- Head-up Display unit
- Windshield
- HUD Switch

The following components are networked together for Head-up display functions:

- **Light Module (LM)** - The light module controls and monitors all vehicle lights. Information is received and transmitted via the K-CAN.
The LM provides the terminal 58g signal via K-CAN. The LM also transmits the dimmer signal to the HUD.
- **Safety and Gateway Module (SGM)** - The SGM provides the gateway between the relevant bus systems for HUD operation. The SGM also provides the means for diagnosis via the D-Bus/SGM pathway.
- **Digital Motor Electronics (DME)** - The HUD receives signals from DME regarding cruise control or ACC. The signals are provided via the K-CAN and PT-CAN.
- **Car Access System (CAS)** - The CAS provides inputs relating to terminal status, the HUD is operational when KL15 is switched ON.
- **Rain/Light Sensor (RLS)** - The RLS has been slightly modified to ensure optimal ambient brightness of the virtual image. The viewing angle of the RLS has been altered to view the area closer to the virtual image. This allows the ambient light near the virtual image to be monitored. This information is provided to HUD via the K-CAN.

- **Instrument Cluster** - The instrument cluster provides vehicle road speed and check control messages via the K-CAN.
- **Cruise Control/Active Cruise Control** - The cruise control or ACC sends the selected driving speed (set speed), distance (ACC), object detection (ACC), regulation display (ACC), and the transfer prompt (ACC) via the K-CAN.
- **Steering Column Switch Cluster (SZL)** - The SZL sends the Cruise Control or ACC requests from the stalk switch via the *byteflight* /SGM/K-CAN pathway to the HUD.
- **M-ASK/CCC** - The navigation information is sent to the HUD. This includes the next road, driving direction arrow, distance to intersection and the bar gauge. These signals are sent via the MOST bus pathway.

HUD Display

The head-up display is installed above the steering column in the instrument panel.

The key components of the head-up display are:

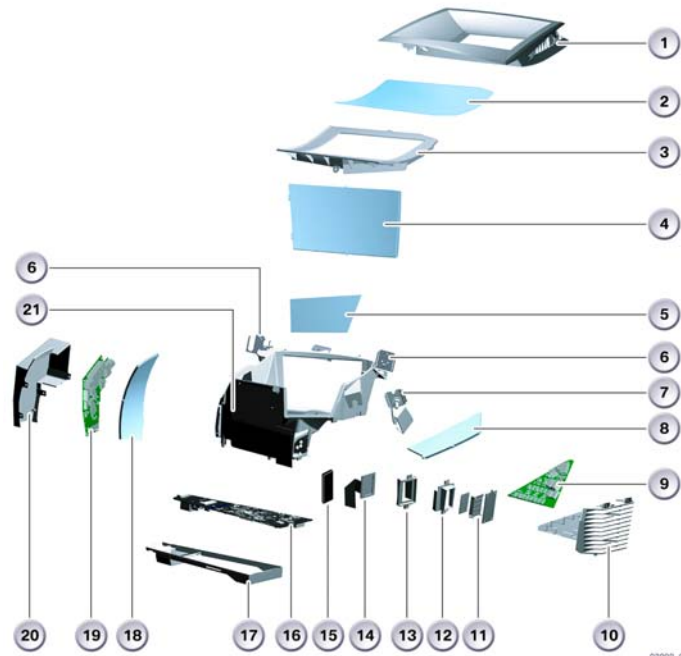
- **4 mirrors** - The 4 mirrors ensure that the contents of the projection display appear at the distance and in the size required, and that deformations caused by the wind-shield are largely compensated for.
- **Light source** - The light source is the back lighting of the projection display. This light source is a number of colored LEDs laid out in rows over a certain area.
The light source is actuated by the electronic circuitry in the head-up display, which also controls the brightness of the display content.
- **Projection display with cover panel** - The projection display with TFT technology (TFT = thin-film transistor) is used to show the display contents. The projection display is activated by the electronic circuitry of the head-up display.
A cover panel protects the projection display when it is switched off.
A stepper motor folds the cover panel out of or into the beam. The stepper motor is actuated by the electronic circuitry in the head-up display.
- **Electronic circuitry** - The electronic circuitry has the task of evaluating and processing incoming image information, generating display content, and the activation of the projection light source and the stepper motor for the cover panel.

The electronics include a temperature sensor which protects the head-up display from overheating. The projection light source is switched off if the temperature exceeds approximately 105°C.

A power supply in the head-up display provides the light source with a voltage of 42 volts, transformed from the on-board supply voltage.

A 12-pin connector on the head-up display creates the connection to the vehicle electrical system.

The MOST data bus is connected to the head-up display via a 2-pin connector.



Index	Explanation	Index	Explanation
1	HUD finisher	12	Light well
2	Cover glass	13	Fixture, TFT projection display
3	Housing frame	14	TFT projection display
4	Curved mirror	15	Shutter
5	Flat mirror (glass)	16	Main board, activation of LEDs
6	Mounting points, front bulkhead	17	Housing frame
7	Adjusting device	18	Curved mirror
8	Curved mirror	19	Secondary board, activation of shutter
9	LED power supply	20	Housing section
10	Heat sink	21	Housing
11	LED array		

The image is formed on the projection display and is illuminated by the light source. The curved mirrors and the flat mirror determine the shape and the size of the projected image.

If the projected image is not level, this can be corrected by turning the projection display with the flexible shaft.

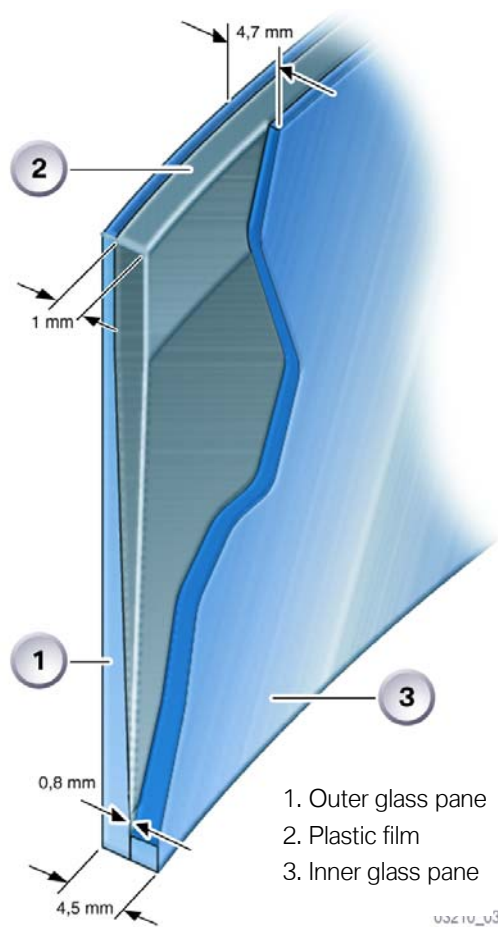
The virtual image appears to float in the air at the end of the hood, approximately 2.2 meters away from the observer. The size of the virtual image is approximately 20 x 10 cm (width x height).

Windshield

The windshield is a "special" windshield and is an integral component vital to projecting the displays. The outer and inner glass panes are connected to a plastic film, which is wedge-shaped over the entire length of the windshield.

The wedge-shape prevents double displays (ghosts) of the HUD by positioning both images one above the other. The wedge tip points downward and starts at a distance of approximately 10 cm to the bottom edge of the windshield.

The end of the wedge is located at approximately 2/3 windshield height. In the top third of the windshield, the plastic film runs parallel to the outer and inner glass panes. The thickness of the wedge tip is 0.8 mm. The thickness of the end of the wedge is 1 mm.



Example of "double image" from use of improper windshield

If a non-specified (normal) windshield is used, the image is reflected on both the outer and inner glass panes. Overlapping causes the image to be displayed twice. The plastic wedge in the windshield places the images of the outer and inner pane over each other thus preventing double displays (ghosts).

HUD Switch

The HUD switch is located next to the headlight switch.



The switch provides two possible functions dependent upon the length of time that the switch is pressed:

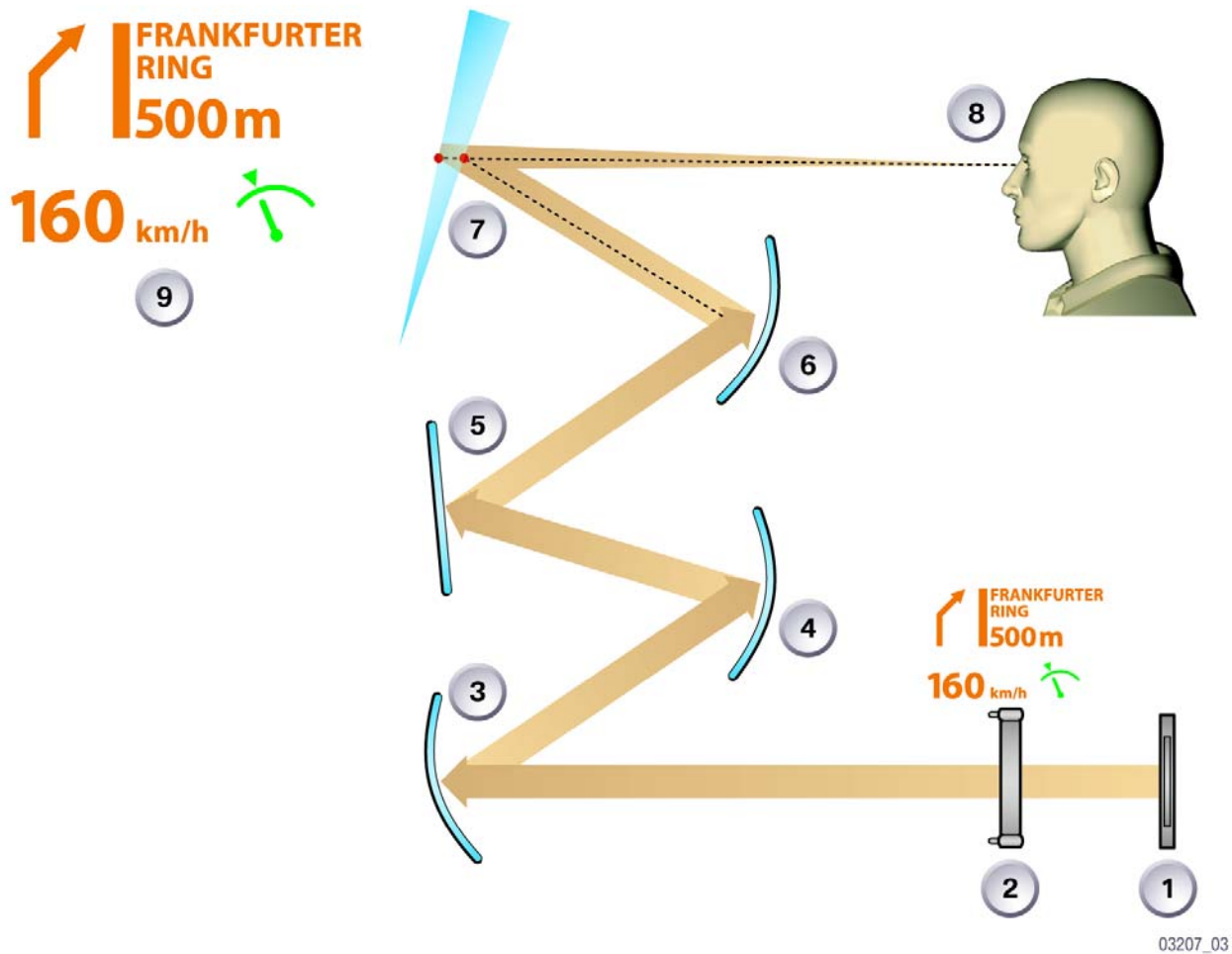
- Pressing the button for less than 10 seconds, switches the Head-up display on or off.
- Pressing the button for more than 10 seconds, activates the test functions for service personnel.
- Once the test functions are accessed, the additional functions can be activated by briefly pressing the button.
- To re-activate the head-up display, press the button again and hold it for longer than two seconds.

The HUD switch is a direct input to the HUD unit. The switch is resistance coded allowing the HUD to identify button faults.

Principle of Operation

The HUD can be compared to a projection device. An LED field is required as the light source for the purpose of projecting the HUD information. The image content is created by the TFT projection display.

The TFT projection display can be compared to a filter which admits or blocks light. An optical imaging element determines the shape and size of the HUD images. The image is projected onto the windshield and appears freely suspended over the road surface.



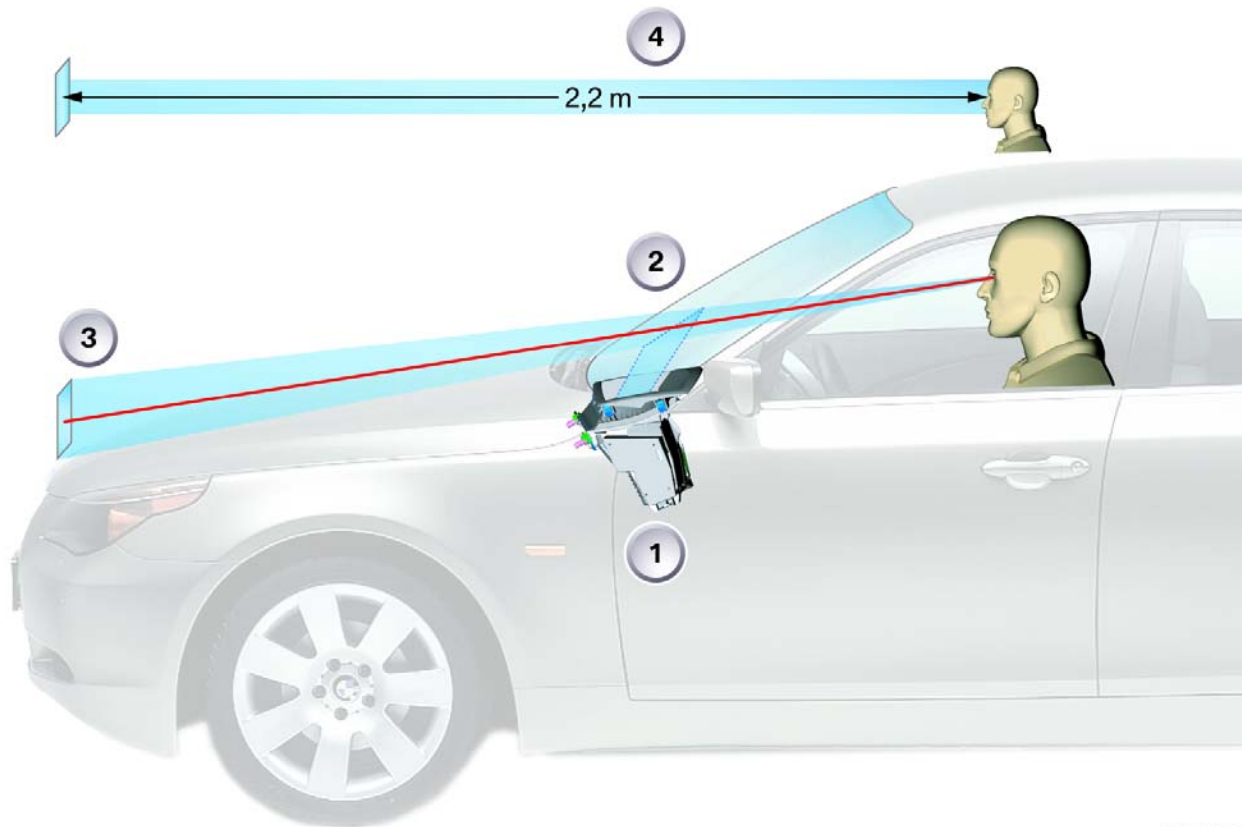
Index	Explanation	Index	Explanation
1	LED array	6	Curved mirror
2	TFT projection display	7	Windshield
3	Curved mirror	8	Observer's point of vision
4	Curved mirror	9	Projected image
5	Flat mirror (glass)		

Mirrors

The HUD incorporates 4 mirrors. These mirrors reflect the display content onto the windshield. Three of the mirrors are curved. These mirrors adapt the display content onto the screen.

This flat mirror determines the size and distance of the HUD projection. The curved mirrors are made of plastic while the flat mirror is made of glass.

The projected HUD image content appears at a distance of approximately 2.2 meters (7.2 feet) from the eye.



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Index	Explanation	Index	Explanation
1	Head-up display	3	Projected image
2	Windshield	4	Projection distance

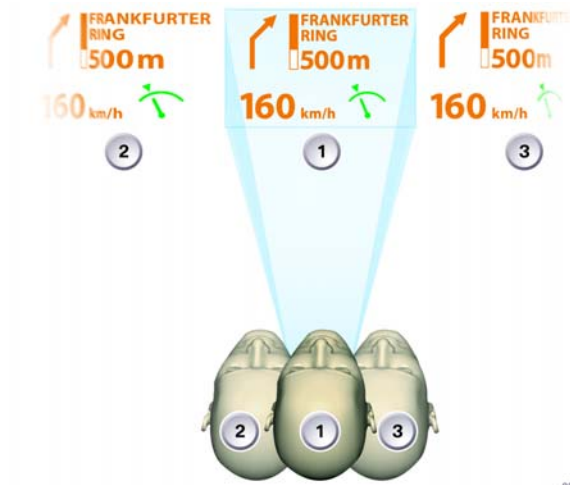
Eyebox

The eyebox is the movement space in which the driver can move without his view of the image in the HUD being impaired.

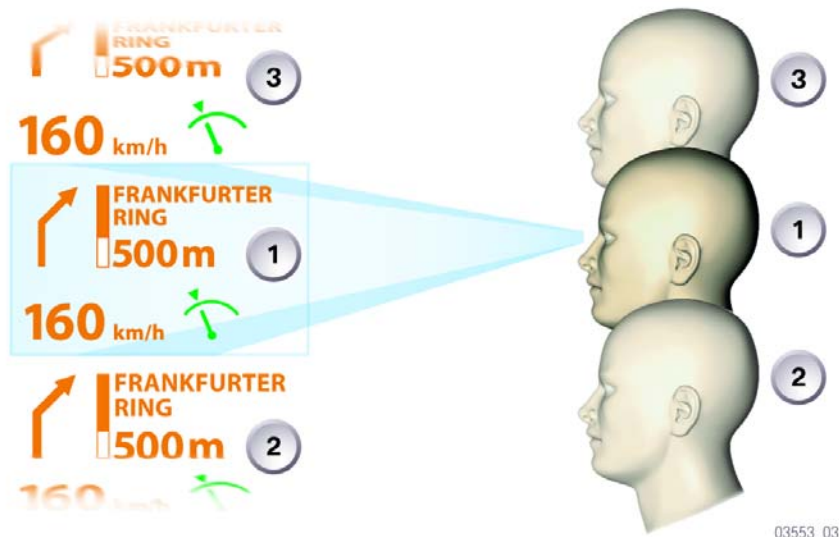
The freedom of movement within the eyebox is roughly:

- 130 mm horizontally
- 90 mm vertically

Outside the eyebox limits the image in the HUD is no longer clearly visible.



1. Point of vision inside the eyebox HUD - **image OK**
2. Point of vision displaced to the left HUD - **image distorted to the left**
3. Point of vision displaced to the right HUD - **image distorted to the right**



1. Point of vision inside the eyebox - **HUD image OK**
2. Point of vision displaced downward - **HUD image distorted downward**
3. Point of vision displaced upwards - **HUD image distorted upwards**

HUD Image Layout

The HUD background color is transparent.

Symbols (such as e.g. warning symbols) are specified by the individual control units. This color specification is adopted for the display in the HUD.

Two dimensional symbols are used for optimum visibility and legibility.

The colors are:

- Orange as the standard color
- Red or yellow for warning messages
- Green for the set speed

The 4 colors are generated by the layout of the LED's and the corresponding actuation of the LED's by the electronic circuitry of the Head-up display.

The size of the virtual image display range is approximately. 20 x 10 cm (width x height). To make the contents of the display easier to read, the display range is divided into an upper section and a lower section. Navigation instructions and Check-Control messages are displayed in the upper section. Speed-related information is displayed in the lower section.

1. Current road speed
2. Navigation instructions consisting of :
 - Driving direction arrow
 - Bar graph
 - Next road
 - Distance to next intersection
3. Set speed
4. Object detection and distance set (ACC)



The signals used to generate the image in the head-up display are input from the corresponding control units, e.g. multi-audio system controller (M-ASK) via the K-CAN and MOST data buses to the electronic circuitry in the head-up display. The electronic circuitry evaluates the incoming signals and forwards the prepared image information to the components in the head-up display.

HUD Function and Operation

The head-up display comprises the following functions:

- Switch-on response
- Projection of virtual image in front of the vehicle
- Automatic adaptation of display brightness
- Prioritization of displays

Switch-on Response

The head-up display is partially operational when terminal R is switched ON. This means:

- The projection display is initialized but information is not yet displayed.
- The head-up display is able to communicate with other bus-elements via the MOST and K-CAN data buses.

The head-up display is operational when terminal 15 is switched ON. This means:

- The light source is switched on when the button for switching the head-up display on and off is pressed.
- The projection display cover panel is folded out of the beam by the stepper motor.
- The automatic adaptation of the display brightness is activated.

Projection of virtual image in front of the vehicle

The head-up display projects a virtual image, i.e. an image that appears to hang in mid-air without a fixed image carrier (e.g. projection screen or similar). The image is generated on the projection display in the head-up display and is projected forwards through the wind-shield to a point in front of the bonnet.

The virtual image is approximately 20 x 10 cm (width x height) and can only be seen from the driver's side.

Automatic adaptation of display brightness

The automatic adaptation of display brightness prevents major sudden changes in the brightness of the head-up display when the vehicle moves between different ambient lighting conditions (e.g. from light to dark and from dark to light when driving through a tunnel).

The automatic adjustment of the display brightness depends on;

- the ambient lighting conditions,
- the brightness adjustment setting,
- the dimmer setting for instrument lighting (only when the lights are on).

The surrounding brightness (day, night, twilight, sunshine, etc.) is recorded by the rain/light sensor. The value of the brightness adjustment (difference between base setting and individually set display brightness) is stored in the head-up display. When the lighting is switched on (terminal 58g, lights ON) the brightness of the head-up display is also influenced by the dimmer setting of the instrument lighting.

Prioritization of Displays

The information in the head-up display is classified according to priority (= importance for the driver). Displays with low priority are overwritten by displays with higher priority.

Priority	Function
1	Warnings from Active Cruise Control (ACC)
2	Check Control Messages
3	Test functions
4	Navigation Instructions

Operation

The head-up display is controlled using the following control elements:

- Button for switching head-up display on and off
- Dimmer for instrument lighting
- Controller for selecting brightness of head-up display in the CID

Switch-on Conditions

The conditions required to switch the head-up display on are:

- Terminal 15 switched on
- Button for switching head-up display on and off switched on

Workshop Hints

The following general information is provided for service staff:

- Test functions
- Replace windshield
- Replace rain/light sensor
- Replace head-up display
- Set head-up display

Test Functions

The test functions are useful for troubleshooting without the DISplus/GT-1.

The test functions are displayed in the head-up display.

Note: Test function replaced when driving. At road speeds greater than 5 km/h, a warning given by the Active Cruise Control or a Check-Control message will replace the test function.

When terminal R or terminal 15 is ON, the test functions will be called up if the button for switching the head-up display is pressed and held for more than 10 seconds. When the first test function is displayed, other test functions can be activated by briefly pressing the button.

Enabling and disabling the test functions

Some test functions are not freely accessible, but rather have to be enabled.

Enabling is only possible in the test function "Enable".

An Enabling is effected by entering the sum of the last 5 digits of the vehicle identification number.

Test functions are disabled again when they are ended.

A test function is, e.g. the system test, which comprises the following sequence:

- The projection display cover panel is folded out of the beam.
- The light source lights up with maximum brightness.
- A series of test patterns appears in the head-up display to check for optical errors. The test patterns make it possible to test readability (focus) and color reproduction. Test patterns contain: Lines, colors, characters and symbols
- The light source is deactivated.
- The projection display cover panel is folded into of the beam.

The test functions are terminated by the following conditions:

- Terminal R OFF
- Button pressed for longer than 2 seconds
- Test function "Reset" called up

Replace Windshield

Important: *A special windshield is needed for the head-up display!*

When changing the windshield, please note that vehicles equipped with HUD require a special windshield.

This windshield is marked with the letters "HUD" at the bottom right edge.

Replace Rain/Light Sensor

Important: *When replacing the rain/light sensor, use only the rain/light sensor for the head-up display!*

The head-up display requires a special rain/light sensor so that the display brightness can be adjusted optimally.

Replacing Head-Up Display

A faulty HUD must be completely replaced. A new HUD must be adjusted once it has been installed. The CID must be removed for this adjustment work.

This adjustment is performed at a screw on the supporting tube. This screw incorporates an eccentric which serves to adjust the angle of the HUD in relation to the windshield.

A special tool is required for adjustment.

Setting Head-Up Display (Adjustment)

There is a 2-piece adjustment tool (62 11 20) for setting the head-up display.

62 11 20 consists of:

1. Projection gauge (62 11 21)
2. Adjustment spanner (62 11 22)

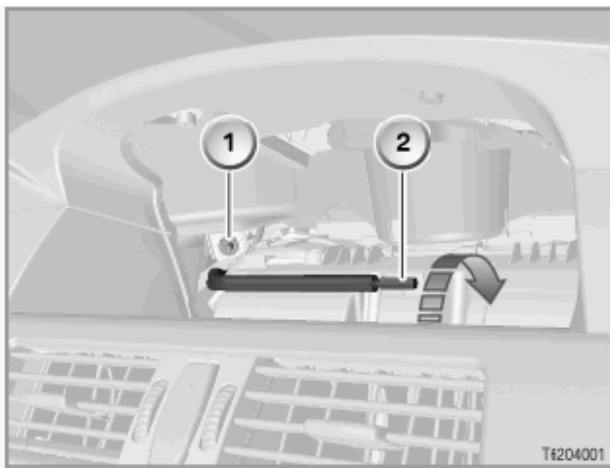
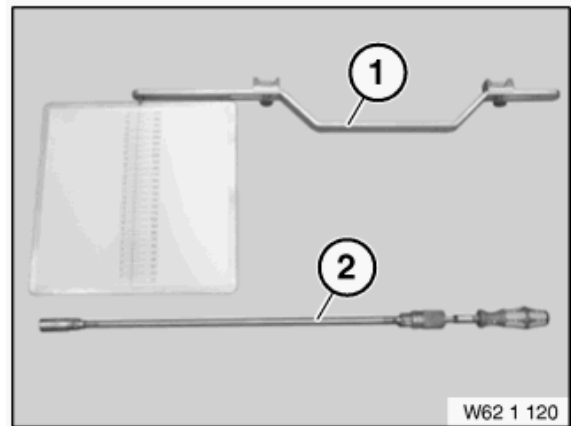
Note: The central information display must be removed to adjust the head-up display.

To access the head-up display adjusting screw with the adjustment tool, the CID must be removed.

Access to the flexible shaft is also only possible once the CID has been removed.

The projection gauge is engaged on the retainers of the sun visors.

With the DISplus or GT-1, the test pattern for setting is called up and projected by the projection display through the windshield and onto the scale of the projection gauge.



1. Screw for height adjustment
2. Flexible shaft

The head-up display can only be adjusted vertically using the adjustment spanner on the adjusting screw.

If the projected image is not level, this can be corrected by manually turning the projection display with the flexible shaft (as of 12/2003).

Important. Rotate the flexible shaft in a clockwise direction only!

Rotate the flexible shaft in a clockwise direction only, as otherwise the display adjustment may break.

Image Defects

Incorrect installation of the HUD or of the windshield may result in faulty HUD projections.

The incidence of light onto the windshield or into the HUD in an inconvenient situation causes the image to fade. Excessive heat in the HUD will also cause the image to fade.



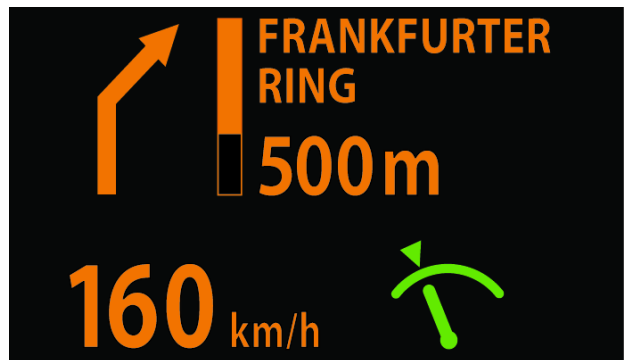
HUD image showing distortion for improper installation or adjustment



HUD image showing distortion for improper installation or adjustment



HUD image showing "double image" from incorrect windshield or incorrect windshield installation



"Normal" HUD image



HUD image showing excessive heat or incidental light



Classroom Exercise - Review Questions

1. What information is displayed on HUD?

2. What vehicles are currently available with HUD?

3. What are the three **main** components of the HUD **system**?

4. What is different about the RLS in HUD equipped vehicles?

5. What special tools are needed to make adjustments to HUD?



Workshop Exercise - HUD Adjustment

Using an instructor designated vehicle, perform the following adjustment procedures on the Head-up Display (HUD). Using Web TIS access the repair instructions for the HUD adjustment.

Access the HUD test functions.

Describe the method/pathway for accessing the HUD test functions:

Activate the System Test.

What is the access number for the tests (sum of VIN)?

What can be found in the system tests?

How can the correct windshield be identified?

Using the DISplus/GT1, perform a short test on the HUD. Perform the HUD adjustments as specified by the repair instructions.

**Note: Do not activate longer than 30 minutes to avoid overheating of the HUD!
Deactivate Test Picture as soon as the adjustment is complete.**

What component(s) must be removed for HUD adjustment?

What special tools are needed for the HUD adjustment?

How many adjustments are possible on the HUD?
